Propofol Drip Infusion Anesthesia for MRI Scanning: Two Case Reports

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The magnetic resonance imaging (MRI) room is a special environment. The required intense magnetic fields create unique problems with the use of standard anesthesia machines, syringe pumps, and physiologic monitors. We have recently experienced 2 oral maxillofacial surgery cases requiring MRI: a 15-year-old boy with developmental disability and a healthy 5-year-old boy. The patients required complete immobilization during the scanning for obtaining high-quality images for the best diagnosis. Anesthesia was started in the MRI scanning room. An endotracheal intubation was performed after induction with intravenous administration of muscle relaxant. Total intravenous anesthesia via propofol drip infusion (4–7 mg/kg/h) was used during the scanning. Standard physiologic monitors were used during scan pauses, but special monitors were used during scanning. In MRI scanning for oral maxillofacial surgery, general anesthesia, with the added advantage of having a secured airway, is recommended as a safe alternative to sedation especially in cases of patients with disability and preoperative children.

Key Words: Magnetic resonance imaging (MRI); General anesthesia; Propofol drip infusion; Children; Developmental disability patients.

The magnetic resonance imaging (MRI) scanning room is a special environment. The required intense magnetic fields create unique problems with the usage of standard anesthesia machines, syringe pumps, and physiologic monitors (electrocardiogram, pulse oximeter, capnograph, and noninvasive blood pressure).^{1–3} Moreover, the scanning procedure lasts around 1 hour. In addition, there is high-level acoustic noise in the MRI room. For the best quality of magnetic resonance imaging and diagnosis, complete immobilization of the patient is needed during scanning, often assisted by general anesthesia or sedation.³ However, special anesthesia instruments made of nonmagnetic

materials needed for MRI scanning are not available at our university dental hospital.

In this paper, we report 2 general anesthesia cases for MRI scanning in our dental hospital using alternative equipment.

PREPARATION BEFORE MRI SCANNING

Some problems are expected when performing general anesthesia in the MRI scanning room. A strong magnetic field and high frequency area are expected to impair monitoring equipment functions, pull the equipment to the magnetic gantry, and burn the skin due to radiofrequency heart-monitoring cables.⁴ Nonmagnetic anesthesia instruments for MRI scanning, such as an anesthesia machine, ventilator, medication pumps, and vital sign monitor, should be required. However, these special machines were unavailable in our dental hospital.

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Therefore, special arrangements needed to be made to provide general anesthesia in MRI scanning rooms. There is a centrally supplied oxygen system, but no gas scavenger system in our MRI room. The MRI system in our hospital is the 0.4T permanent magnet open MRI system (APERTO Inspire, Hitachi Medico Co, Ltd). The system has an MRI exclusive use electrocardiograph (MRI-ECG) lead wire pulse grip sensor cable and MRI electrode pads that are made from nonmagnetic metals and materials. The MRI-ECG measures only R wave signals of the electrocardiograph using the MRI electrode pads attached to the patient's chest, which reduces flow artifacts and skin burning. The wave on the screen at the MRI control desk looks like a pulse wave rather than a typical ECG tracing. The MRI-ECG is endorsed to a time limit of 5 minutes during scanning with a pause of more than 3 minutes between scanning for cooling. Other physiologic monitors such pulse oximeter, capnograph, and noninvasive blood pressure were only used between each scanning time (magnet activation). Each scanning time was for 5–6 minutes with a resting time for 3- to 5-minute intervals. The anesthesia machine used (PIVOT air/water Co, Ltd; $60 \times 65 \times 137$ cm, 33.5 kg) was the smallest one in our hospital. We dismantled pieces of the machine from its stand: the standard physiologic monitoring system, oxygen and nitrous oxide cylinders, and ventilator for risk management.

The design of our MRI scanning room is shown in Figure 1. There is the strong magnetic force around the magnetic gantry at all times, even if the MRI scanner is

not turned on. The anesthesia machine is positioned about 2 m from the center of the magnetic gantry as in the design and anchored. We were able to test the magnetic power of the gantry by the lifting of a stationary paper clip. At this position, the anesthesia machine displayed no metal reaction and appeared to be at an appropriate distance from the magnet.

For simulation, we scanned one of our staff members to obtain three MR images (Figure 2), with and without anesthesia instruments in the room. We checked compatible instruments for general anesthesia in the MRI room. A restraining device (called restrainer) which was a board with straps and cloth to immobilize a patient was used during the scanning. Number 1 in Figure 2 was scanned with the anesthesia machine, physiologic monitor, and syringe pump in the room. This is a partial imaging. The physiologic monitor was removed for imaging Number 2. Number 2 produced superior images to Number 1. The physiologic monitor and syringe pump were removed for Number 3, which produced the best imaging of the three. The restrainer was speculated not to affect the image at this trial.

The instruments permitted for usage in the MRI scanning room are shown in Table 1. The highlighted gray field area in Figure 1 indicates the strongest magnetic power, and device failure happens at more than 0.5 mT (about 2 m far from the center of the gantry). As the exclusive use of the MRI-ECG cable and MRI electrode pads could be applied safely, the pulse waves and pulse rates from the device were used to

Figure 1. Design for magnetic resonance imaging (MRI) scanning room. Device failure happens in the magnetic field of the room, and the highlighted gray area (black arrow pointing area) has the strongest field at more than 0.5 mT. (1) MRI scanning system, (2) bed for patient, and (3) control table.

Figure 2. Pre-magnetic resonance imaging (MRI) scanning for simulation. Three MR images are shown, with and without anesthesia instruments in the room.

monitor during MRI scanning. The anesthesia machine, laryngoscope, and stethoscope could be used more than 2 m from the center of the magnetic gantry in the room. However, we could not use the standard physiologic monitoring system, a syringe pump, nor a capnometer during the scanning because of image artifacts. These monitors were placed in a room adjacent to the MRI scanning room, and connected with a long extension tube. The monitoring screen could be seen in the MRI room through an observation window. We determined the minimum required anesthesia equipment required during scanning was the anesthetic machine with breathing bag and the MRI-ECG. The other equipment for anesthesia and emergency drugs were ready in the room adjacent to the MRI room.

CASE 1

A 15-year-old boy (height 146 cm, weight 32 kg) with developmental disability had a right-sided buccal tumor, which was suspected to be malignant. He could understand spoken words but did not have verbal language skills. Also, he has a special sound phobia: he goes away or cries when he hears sounds like motorbikes or vacuum cleaners.

Ten milligrams of diazepam was administered orally as a premedication 1 hour before entering the room. Table 2 shows the methods of anesthesia and monitoring equipment. We started general anesthesia more than 2

m from the center of the gantry near the entrance in the MRI room. Standard vital sign monitoring with MRI electrode pads was used for anesthesia induction. The intravenous infusion line was inserted in the MRI room. The intravenous pole stand holding the infusion bottle was a nonmagnetic metal made specifically for MRI. At first, a bolus of 60 mg of propofol was administered, intravenously. Then, we started a propofol drip infusion (4–5 mg/kg/h) using the 60 drips per 1 mL drip infusion tube with 100% oxygen by mask. Thirty milligrams of rocuronium bromide was used as a muscle relaxant for oral intubation with the aid of neuromuscular monitoring. The endotracheal tube was fixed on the corner of his left mouth and lower jaw by adhesive tape. Propofol 10 mg/mL was diluted with 5% glucose to 2 mg/mL in a bottle for drip infusion as permitted in Japan (note: must be used within 6 hours). The dose of propofol was controlled by the speed of the drip.

Controlled manual ventilation by an anesthesiologist in the scanning room was used to maintain respiration with 100% oxygen in the MRI room. During MRI scanning, the pulse and body temperature were checked by palpation (Figure 3). We were able to effectively perform MRI. Anesthesia time in the MRI room was 1 hour and 20 minutes. No respiratory and circulatory complication occurred. A tumor was diagnosed, and the patient was relocated to the outpatient surgical room after the scanning where a biopsy was performed. General anesthesia was maintained by total intravenous anesthesia using a computerized syringe pump and standard

Table 1. Equipment for Usage in the Magnetic Resonance Imaging (MRI) Room

○	MRI exclusive use ECG monitor with MRI system*
○	restrainer: a board with straps and net to immobilize a child
△	anesthesia machine (PIVOT: air/water Co. Lit.)
△	laryngoscope
△	stethoscope
○	MRI exclusive use electrode pad: nonmagnetic metals
×	physiological monitor system (automatic measurement)
×	syringe pump
×	capnometer

○ : usable

△ : usable outside of the highlighted gray color area (more than 0.5 mT) in Figure 1

× : unusable

* MRI-ECG monitor measures R wave signals in cardiogram synchronized with pulse waves

monitors. Diagnosis by biopsy confirmed rhabdomyosarcoma.

CASE 2

A healthy 5-year-old boy (height 96 cm, weight 13 kg) showed left upper lip enlargement. General anesthesia with endotracheal intubation was selected to avoid movement during MRI scanning due to his age. The anesthesia machine was the same as in case 1. It was placed in the same location as before. Anesthesia was induced using sevoflurane inhalation in the MRI room. Then, a tracheal tube was inserted orally after intravenous administration of rocuronium bromide. Total intravenous anesthesia with 6–7 mg/kg/h propofol drip infusion was started and adjusted during the scanning with controlled manual ventilation provided by the dental anesthesiologist in the MRI scanning room. A restraining device as in case 1 was used, but of a smaller size. However, it may have caused an artifact in the MR image. It did not appear that there was any metal on the device used in this case, but

we felt the catches may have interfered with the magnet. We scanned again without the restrainer and were then able to obtain higher quality images. As in the previous case, visual monitoring through the observation window as well as visualization of the exclusive-use pulse monitor (MRI-ECG) with the MR scanning system on the MRI control desk was used. Anesthesia took 1 hour and 40 minutes. After the scanning, standard vital sign monitors were attached to the patient and depth of neuromuscular blockade assessed. When spontaneous respiration and vital signs were stable, extubation was performed in the MRI room. Reversal of muscle relaxant was not required. There were no respiratory and circulatory complications. A tumor suspected of being a lymphangioma of the left upper lip was confirmed.

DISCUSSION

MRI scanning is a relatively noninvasive procedure. However, during MRI scanning, immobilization is required for approximately 1 hour in an enclosed space

Table 2. Methods of General Anesthesia and Monitoring Equipment: Case 1*

Anesthesia time: 2hr 15min Time in the MRI room: 1hr 20min Time in out-patient operation room: 50min		
	General Anesthesia	Monitoring
induction	propofol 60mg bolus iv →propofol drip infusion (4~5 mg/kg/hr) Intubation : rocuronium Br 30mg iv	standard physiological monitor [ECG blood pressure pulse oximeter capnometer neuromuscular block monitor
maitenance (during MRI scanning)	propofol drip infusion (3~4mg/kg/hr)	blood pressure } MRI scanning pulse oximeter } is not turned on capnometer } MRI ECG (pulse wave monitor)
patient relocated	propofol 50mg bolus iv →propofol drip infusion (4~5 mg/kg/hr)	pulse oximeter
biopsy	TIVA with syringe pump	standard physiological monitor

with a 90 dB or louder noise. This is relatively stressful even for healthy adults. There was concern about cooperation while scanning in our 2 cases: case 1, a 15-year-old boy with intellectual disability who also had a strong fear of loud sounds, and case 2, a healthy but potentially preoperative 5-year-old child. Complete immobilization is required as respiratory assistance is difficult during cephalic imaging and the movement of even soft tissue may lead to blurred images. Therefore, we selected general anesthesia with endotracheal intubation rather than intravenous moderate sedation or nonintubated general anesthesia, following the protocols of the American Society of Anesthesiologists.¹

Devices for anesthesia to be used in the MRI room must be of nonmagnetic materials. The devices must be able to perform without influencing the scanning or being influenced by the magnetic field. When an electric instrument is placed close to the 0.5 mT or higher magnetic field area, malfunction may occur.^{1,2} The functions of a watch, pacemaker, and nerve stimulator may be affected. In 1 report, a metal gas cylinder was attracted by the strong magnetic force and destroyed an MRI system.⁵

Other reports indicate that the high-frequency electric power-related generation of heat in the monitoring cables can burn the skin in contact with the cables. Looped cables have caught fire.⁶ There is a report of a tattoo-induced skin burn.⁷ Additionally, there are some reports of bite blocks, spiral endotracheal tubes, and even cerebral artery clips either completely removed or displaced in the MRI room under general anesthesia.^{8,9} Due to these reports, we undertook a risk mitigation strategy. We dismantled pieces of the anesthetic machine such as the stand and attached monitors before moving it to the MRI room. When providing anesthesia without standard monitors in the MRI room, patient safety is of paramount importance. We determined the minimum necessary instruments that we felt were appropriate, and prescanning as a simulation was conducted in each case. Considering the closed nature of the MRI room with minimum air circulation, use of intravenous anesthesia with propofol and 100% oxygen was felt to be preferable as even with gas scavenging, some environmental gas pollution could occur.

Some studies, however, have shown the percentage of MRI interruption in a propofol group was significantly higher than that in a sevoflurane group.¹⁰ Another study,

Figure 3. Photo in the magnetic resonance imaging (MRI) room during MRI scanning under general anesthesia. During MRI scanning, the pulse and body temperature were checked by palpation. Propofol was dripping by gravity from the bottle using a 60 drips/mL infusion tube.

however, compared primary outcomes of frequency of pausing the MRI scan, agitation, and respiratory complications between the 2 groups: general anesthesia with sevoflurane or propofol via laryngeal mask airway. They found no difference in respiratory complications. However, the propofol group had less agitation than the sevoflurane group but increased MRI scan pauses.¹¹ In our cases, total intravenous anesthesia with propofol drip infusion was selected because there were no special anesthesia instruments for the MRI room and no anesthetic gas scavenger system. Propofol (1% Propofol inj. “Marushi,” Maruishi Pharmaceutical Co, Ltd, Osaka, Japan) was diluted with 5% glucose solution to a concentration of 2 mg/mL, as described above. During the drip infusion, it can be more difficult to regulate the administered dose than with an infusion pump. Remifentanyl could be considered for anesthesia stability, but concern over hypopnea and apnea exist especially with this drip infusion method. In order to maintain safe levels of anesthesia during MRI scanning, the anesthesiologists continued to observe the pulse rate with the use of a specialized heart rate monitor (MRI-ECG). Body temperature was monitored by palpation. Additionally, since the ventilator was removed from the anesthesia machine, controlled ventilation was maintained manually with 100% oxygen, and changes in respiratory pattern could

be easily determined. Other physiologic monitors such as pulse oximeter, capnograph, and noninvasive blood pressure were used for 3- to 5-minute intervals between each scanning session of 5–6 minutes.

It is very important to select an anesthetic method and establish a safe protocol during MRI scanning. Malviya et al¹² reported that sedation of children for MRI and CT scanning is associated with risks of hypoxemia and of inadequate or failed sedation. Shorrab et al¹³ reported that MRI could be safely performed with intravenous sedation using midazolam, ketamine, and propofol, excluding infants aged 11 months or younger. Tith et al¹⁴ concluded that the use of a pentobarbital technique was found to be associated with a lower incidence of complications during sedation in noncardiac MRI patients compared to a propofol technique or a pentobarbital technique requiring supplemental sedation. Although endotracheal intubation can be avoided, airway complications during MRI scanning may lead to a fatal outcome with scanning of the oral region. In small children and patients with developmental disability, general anesthesia with endotracheal intubation may be selected rather than intravenous sedation to obtain complete immobilization.

In a recent study,¹⁵ pediatric sedation/anesthesia with propofol for procedures outside the operating room is

unlikely to yield serious outcomes in a collection of institutions with highly motivated and organized sedation/anesthesia services with trained personnel. However, the safety of this practice is dependent on a system's ability to manage less serious events. In oral maxillofacial surgery, the head is located at the gantry center of the highest magnetic-field area, and special anesthetic devices are unavailable in Japanese dental hospitals. Airway management with endotracheal intubation may make MRI scanning more successful with minimal adverse events. In addition, pre-MRI scanning conferences with cooperating staff—oral surgeons, dental radiologists, radiological technicians, dental anesthesiologists, and staff supporting the environment—are very important for optimal scanning without adverse events.

In conclusion, we report 2 cases of general anesthesia for MRI scanning. In MRI scanning for patients with developmental disability and/or small children, general anesthesia with endotracheal intubation using propofol drip infusion can be safe and useful. The image quality was markedly improved and scan times may be reduced. It is important to simulate MRI scanning for the best results before general anesthesia, especially if exclusive equipment is not available at the hospital.

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